



# **KATZEN**

INTERNATIONAL, INC.

## **Technology & Engineering**

**Cincinnati, Ohio U S A**

**Philip W. Madson**  
**President**

# **FUEL ETHANOL FEEDSTOCK CHALLENGES**

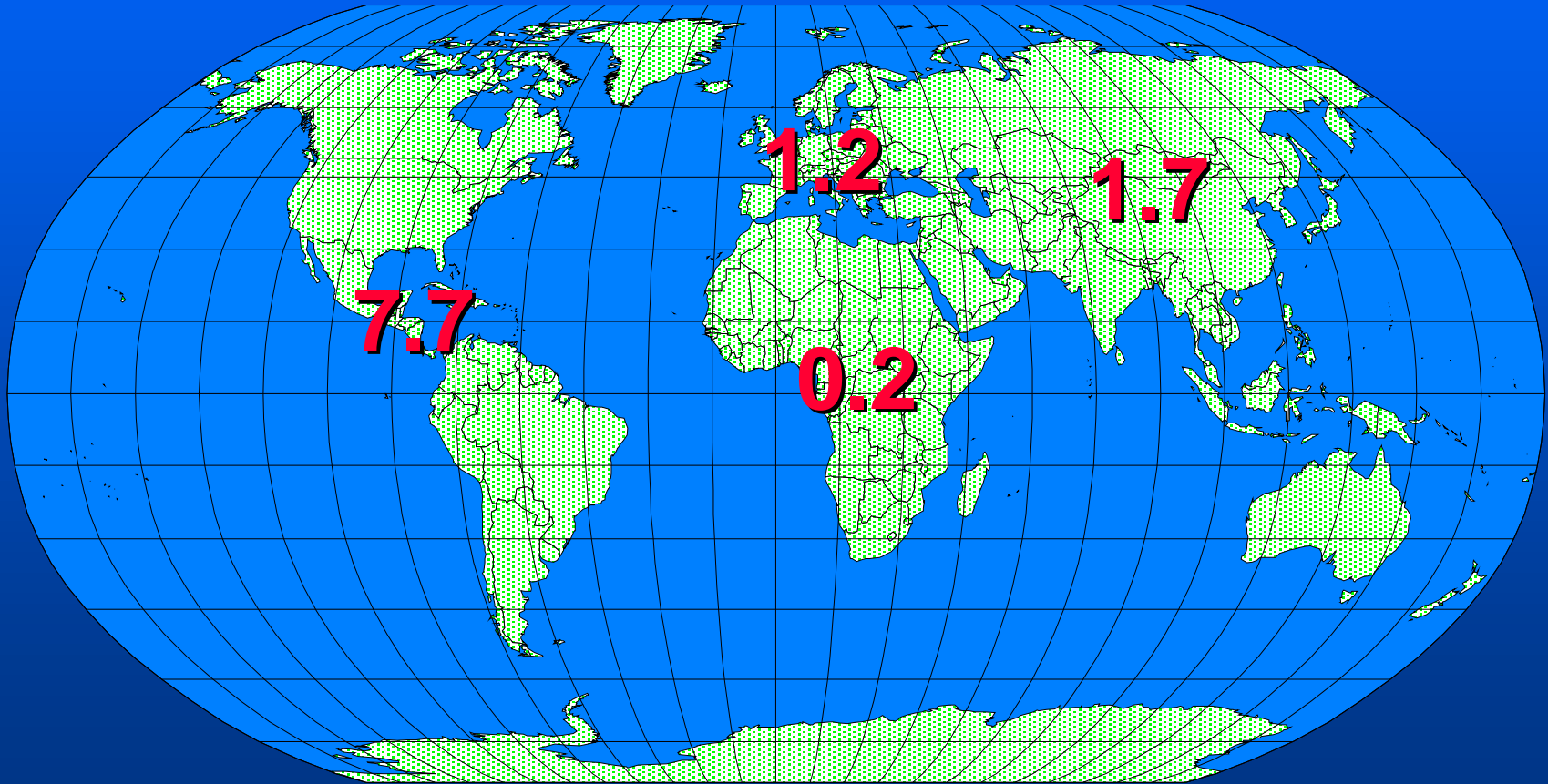
**WHEAT / BARLEY / CORN**

# **MORE THAN 6,000 ETHANOL PLANTS WORLDWIDE**

**SOURCE: DR. JOHN MURTAGH**

# ETHANOL PRODUCTION

(BILLIONS OF GALLONS)



SOURCE: F.O. LICHT

# BIOETANOL GALICIA

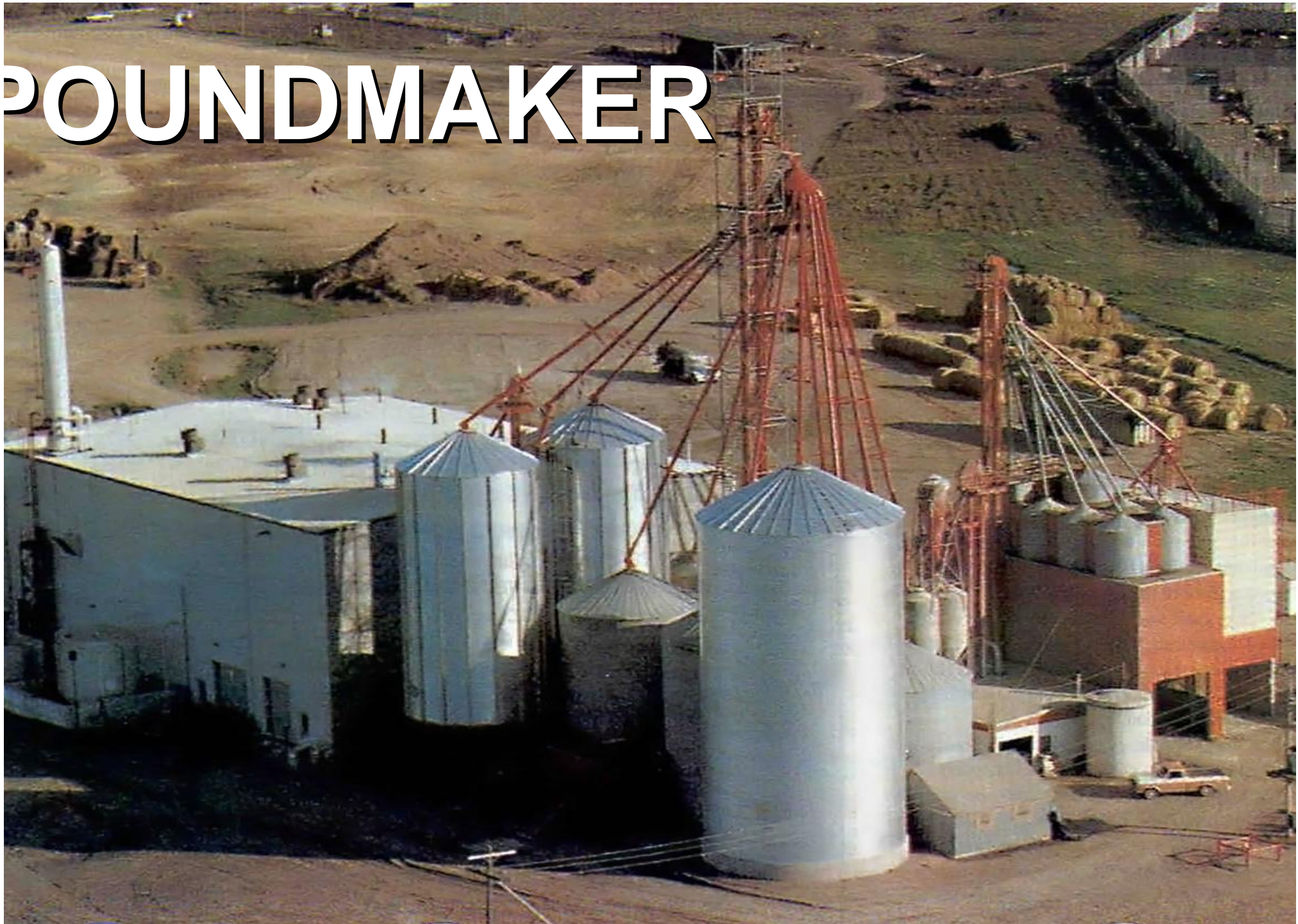


# TARKIM





# POUNDMAKER





MGP





# CASTILLA y LEON



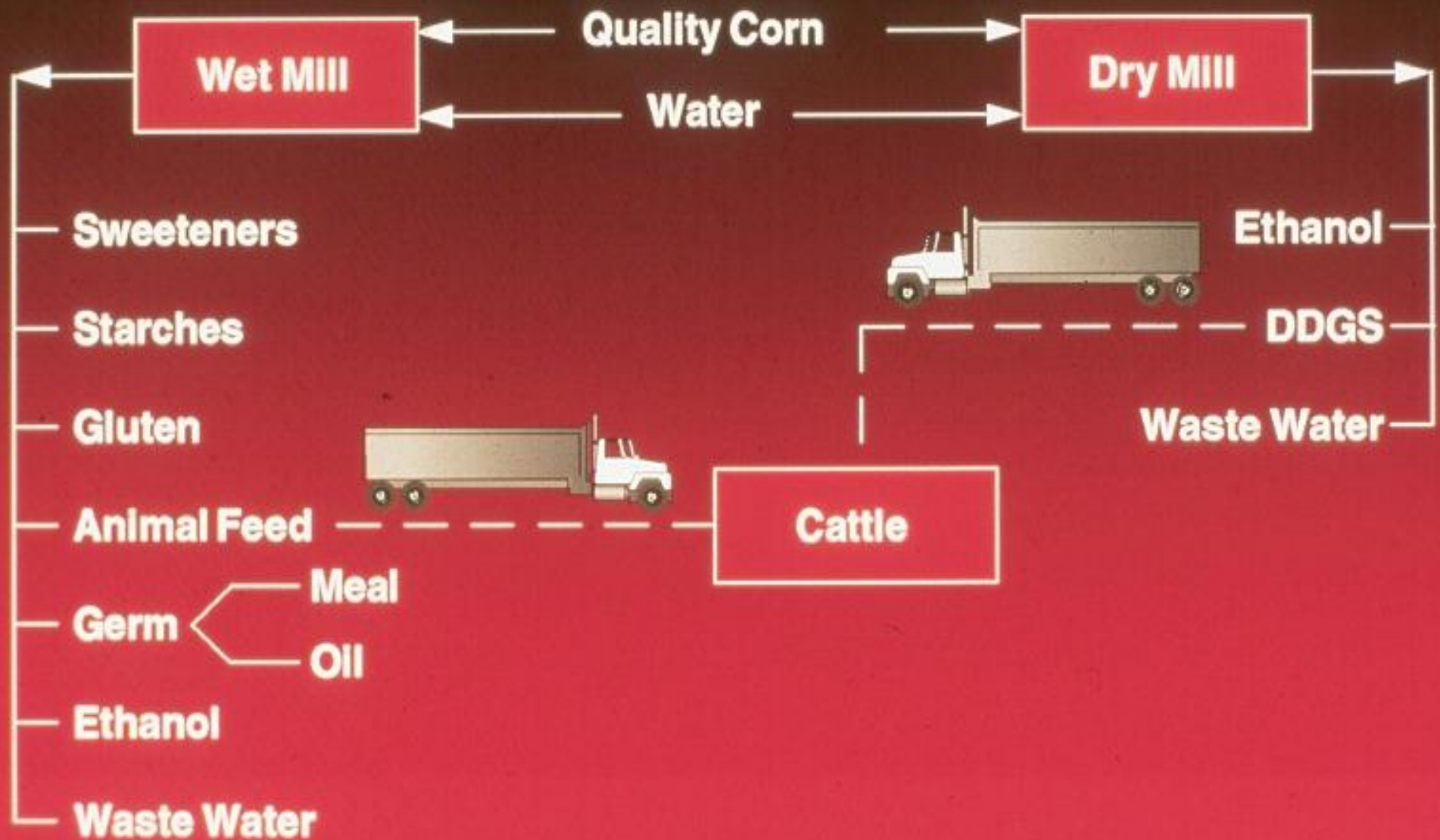


# Husky





# CONVENTIONAL ETHANOL PROCESS OPTIONS



# REEVE



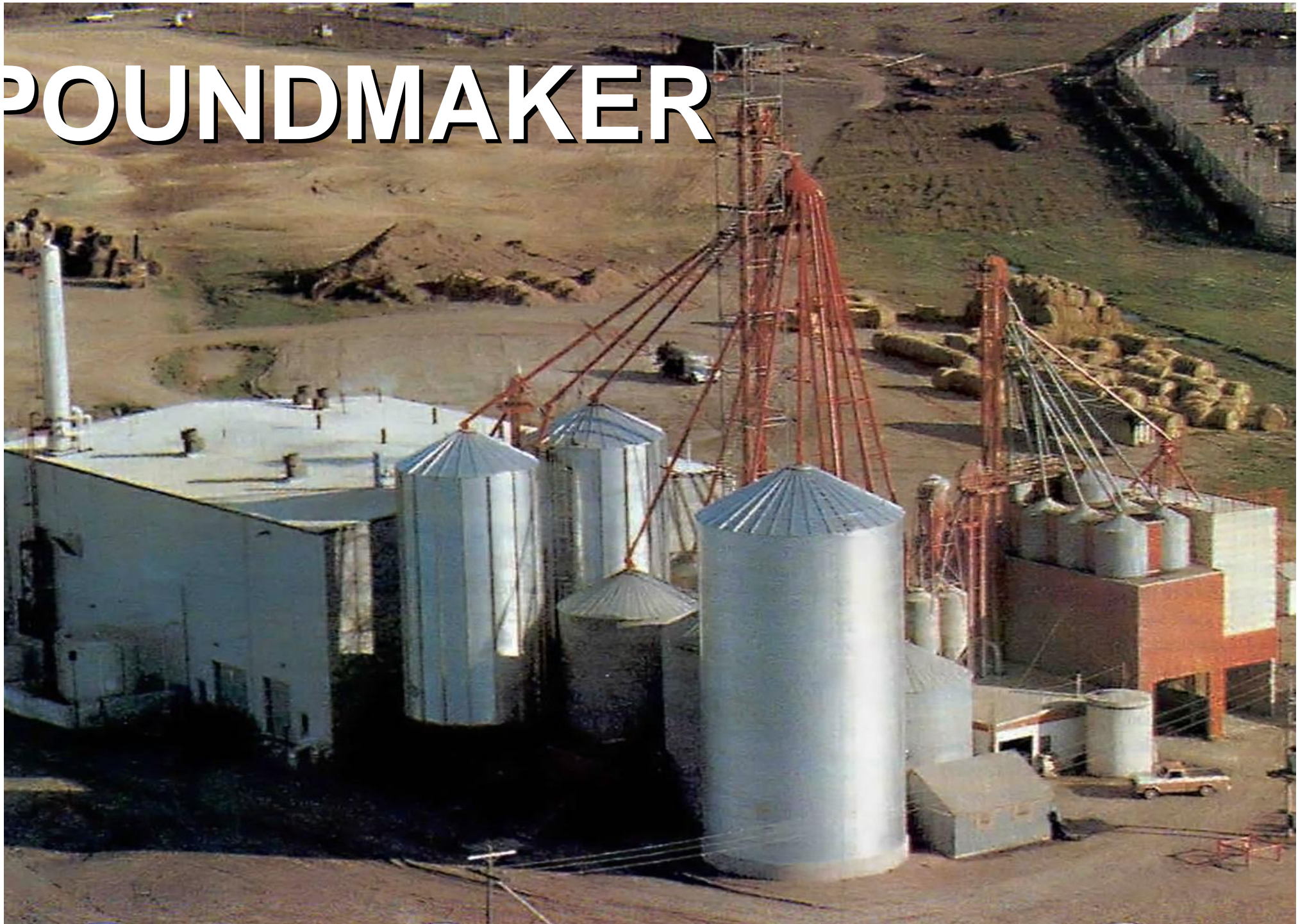


# WDG

	<b>“New Generation” <u>Plant</u></b>	<b><u>Reeve Agri-Energy</u></b>
n <b>PROTEIN</b>	<b>31</b>	<b>41</b>
n <b>TDN</b>	<b>84</b>	<b>86</b>
n <b>CRUDE FIBER</b>	<b>6</b>	<b>8.5</b>
n <b>GLUCOSE</b>	<b>0.65</b>	<b>ND</b>
n <b>SUCROSE</b>	<b>0.55</b>	<b>ND</b>
n <b>LACTIC ACID</b>	<b>1.2</b>	<b>0.3</b>
n <b>GLYCEROL</b>	<b>4.8</b>	<b>1.1</b>
n <b>ASH</b>	<b>6</b>	<b>2.4</b>

**(% - Dry Basis)**

# POUNDMAKER



# KATZEN EXPERIENCE WITH WHEAT \*

- n MIDWEST GRAIN - KANSAS
- n REEVE - KANSAS
- n MOHAWK - MANITOBA
- n MANILDRA - IOWA, AUSTRALIA
- n POUND-MAKER - SASKATCHEWAN
- n API / PERMOLEX - ALBERTA
- n BIOETANOL GALICIA - SPAIN
- n TARKIM - TURKEY

\* (or WHEAT STARCH)

# KATZEN EXPERIENCE WITH BARLEY

n COLORADO AG  
(Barley and Potatoes)

n MOHAWK

n POUND-MAKER

n BIOETANOL GALICIA

- *COLORADO*

- *MANITOBA*

- *SASKATCHEWAN*

- *SPAIN*



# **TECHNICAL DEVELOPMENTS**

**in the  
Production of Ethanol**

**YIELD**

# ETHANOL YIELD FROM CORN

(UNDENATURED)

	<u>Gal./bu.</u>	<u>L./Tonne</u>
1970's	2.5	370
1980's	2.65	390
1990's	2.75+	410

NOTE: 2.8 GALLONS PER BUSHEL (415 LITERS PER TONNE)  
DEMONSTRATED

**WHEAT AND BARLEY  
EXPERIENCE YIELDS  
PROPORTIONAL TO  
STARCH CONTENT**



# SSF

## SIMULTANEOUS SACCHARIFICATION AND FERMENTATION

U. S. PATENT # 4,224,410  
1980

- BEST FOR DRY MILLED GRAIN

# **FERMENTATION TECHNOLOGY U.S.A.**

**n Total - 81 Plants**

**– Wet Mills - 10**

**\* Cascade - 9**

**\* SSF - 1**

**– Dry Mills (or equal) - 71**

**\* Cascade - 9**

**\* SSF - 62**

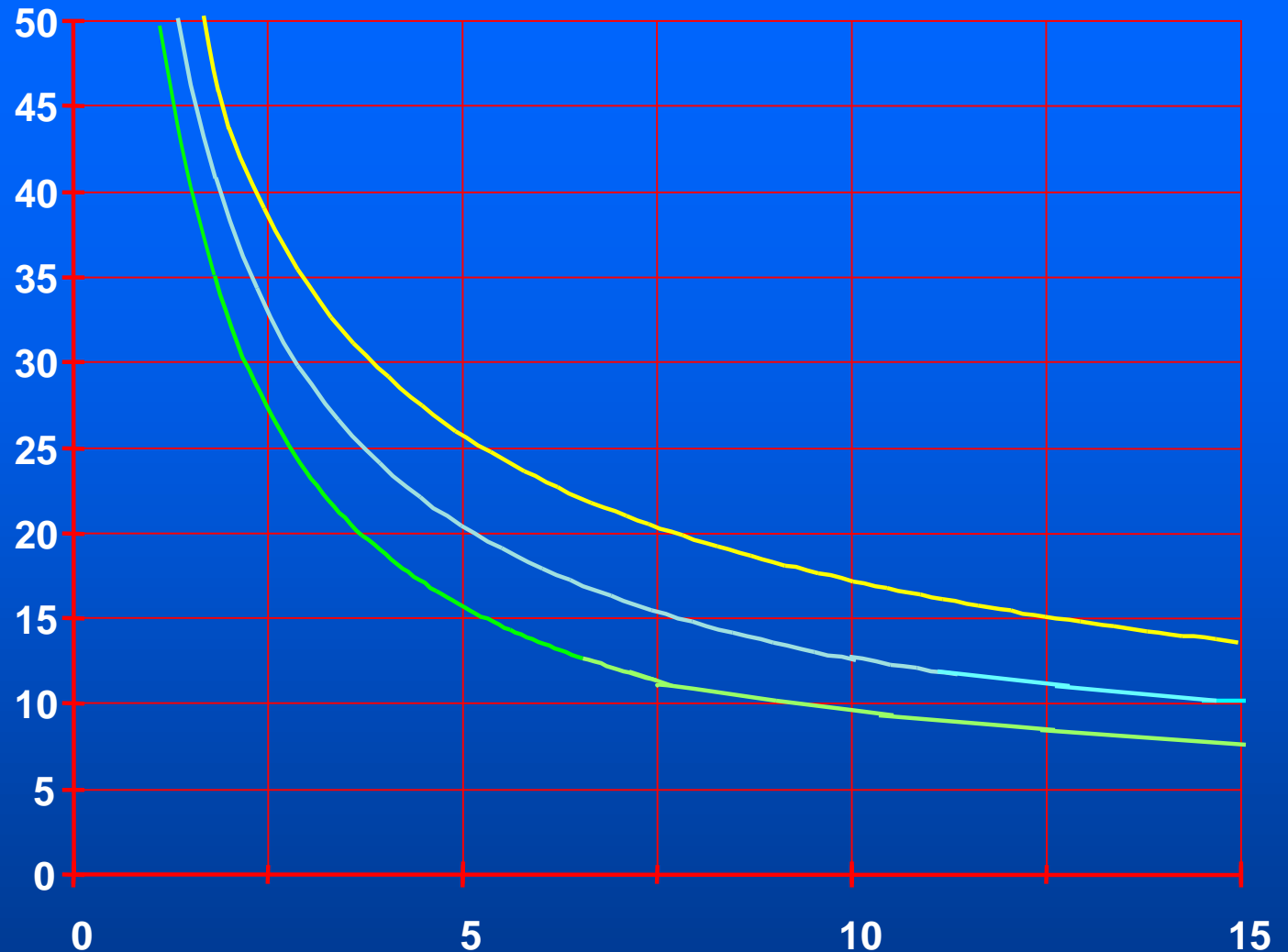
**ENERGY**

# **DISTILLATION ENERGY CONSUMPTION**

# **TWO - LEVEL ENERGY CASCADE**



**BTU (In 1000's)  
PER GALLON  
ETHANOL  
(ANHYDROUS  
BASIS)**



**BEER CONCENTRATION  
(VOLUME %)**

CONSTRAINTS:

- 190 PROOF PRODUCT
- 0.02% (WT.) BOTTOMS
- SATURATED FEED

# **MOLECULAR SIEVE DEHYDRATION**

- U VAPOR PHASE ADSORPTION**
- U NO ENTRAINER**
- U LOW ENERGY**



# **DISTILLATION / DEHYDRATION TECHNOLOGY**

	<u><b>TYPE</b></u>	<u><b>DEHYDRATION TECHNOLOGY</b></u>	<u><b>ENERGY (BTU / Gal)</b></u>
<b>1970's</b>	<b>STANDALONE</b>	<b>AZEOTROPIC</b>	<b>34,000</b>
<b>1980's</b>	<b>INTEGRATED COMPLEX</b>	<b>AZEOTROPIC</b>	<b>17,000</b>
<b>1990's</b>	<b>FULLY INTEGRATED "USER FRIENDLY"</b>	<b>MOLECULAR SIEVE</b>	<b>14,000</b>
<b>2000's</b>	<b>ADDITIONAL INTEGRATION</b>		

# TOTAL ENERGY BALANCE CORN IN USA

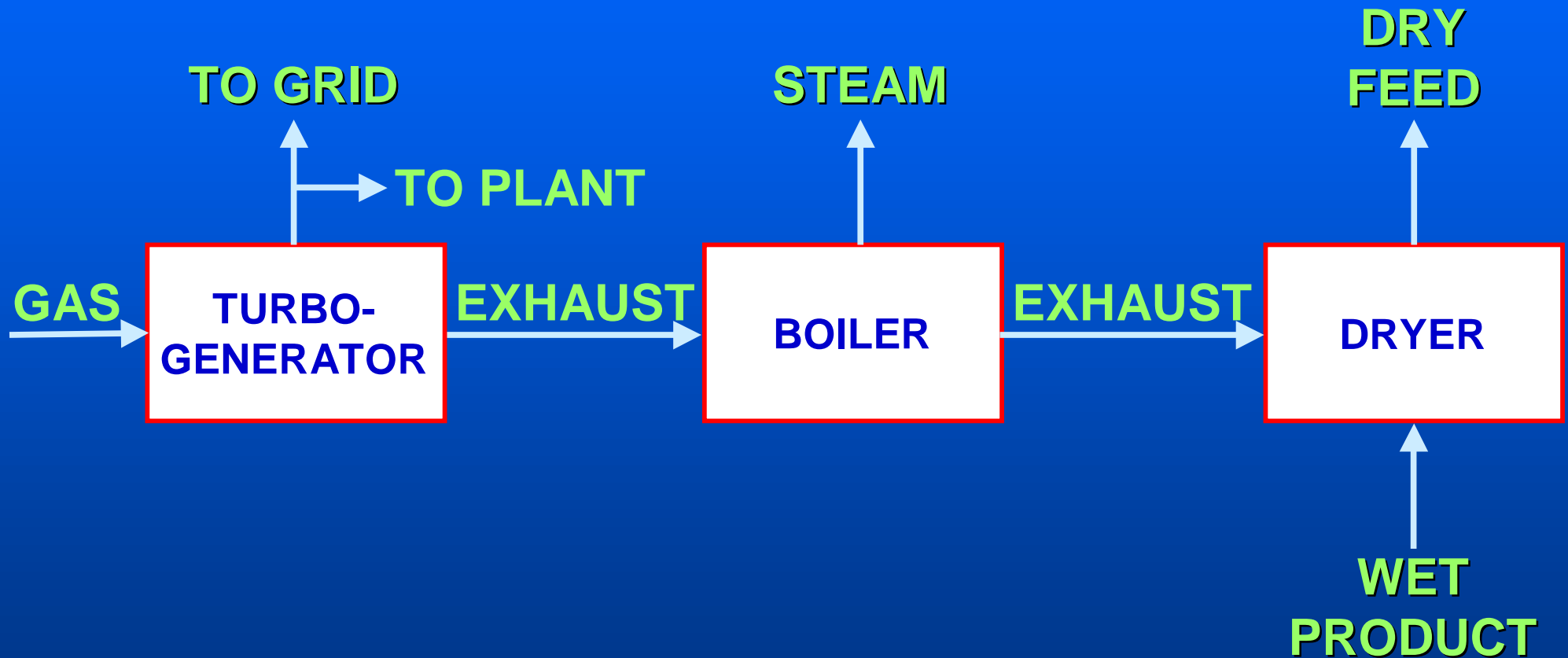
- n 67% More energy in Fuel Ethanol than required for production
- n 1.67 to 1 Energy ratio

SOURCE: USDA



# **ALTERNATIVE ENERGY PROJECTS**

# ABENGOA





# **MANURE DIGESTION FOR BOILER FUEL**



E<sup>3</sup>



# **FEEDSTOCK ISSUES**

# EXAMPLE

## 20 MM GPY PLANT

	FEEDSTOCK <u>Ton/Yr</u>	DDGS <u>Ton/Yr</u>	PRO-FAT <u>% BD</u>
WHEAT	210,000 (+8%)	70,000 (+26%)	34 - 40
BARLEY	234,000 (+21%)	98,000 (+77%)	28 - 34
CORN (base)	194,000	55,500	39 - 43

# ENZYMES REQUIRED

CORN 3

WHEAT > 4 \*  
BARLEY

\* Added beta-glucanase, xylanase  
(+1 to 2 cents per gallon)



# WHEAT vs. CORN PLANT

INVESTMENT	+ 5 - 10 %
OPERATING COST	+ 2 - 3 CENTS PER GALLON
DDGS < QUANTITY	+ 25 - 30 %
QUALITY	LOWER PRO-FAT
<i>- WHEAT PLANT WORKS WITH CORN BUT NOT WITH BARLEY</i>	

# BARLEY vs. CORN PLANT

INVESTMENT

+ 20 - 30 %

OPERATING COST

+ 4 - 6 CENTS PER GALLON

DDGS < QUANTITY  
QUALITY

+ 70 - 80 %

VERY LOW PRO-FAT  
and PALATABILITY

- *BARLEY PLANT WORKS VERY WELL  
WITH WHEAT OR CORN*

# **CELLULOSE** **as** **FEEDSTOCK**

**WHY ?**

**What is the most abundant  
organic molecule on earth?**

**Cellulose!**



**When will the**

**“FIRST”**

**Cellulose – to – Ethanol**

**Plant be built**

**???**

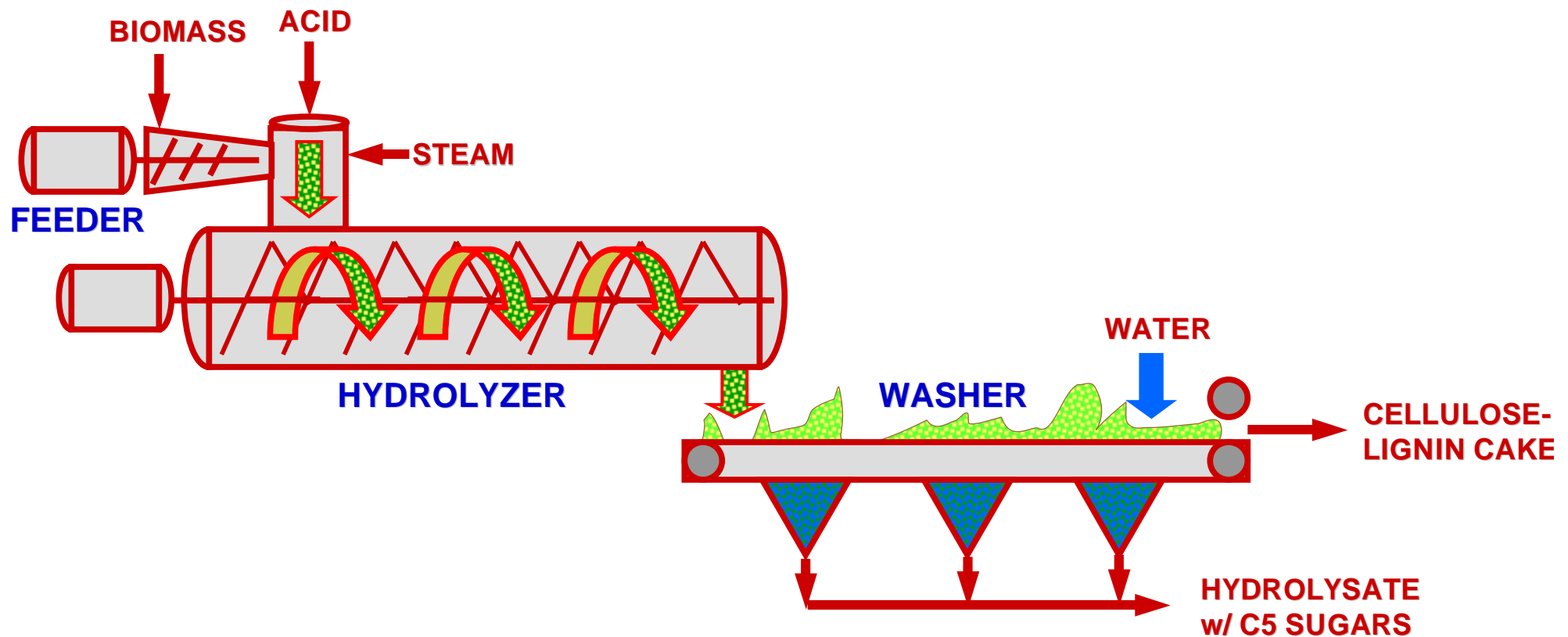
# CELLULOSE - TO - ETHANOL

- 1898 - Germany - 50 Gallons/Ton
- WWI - USA - 2 Plants
- 1932 - Germany - Scholler Process
- WWII - USA - KATZEN Plant
- 1952 - Germany - Improved Process  
Russia - (Operating – 2004)  
Japan
- 1985 - World - Technology Understood  
Uneconomic
- 2005 - World - Near Term

# **MILD ACID/ ENZYME SYSTEM**

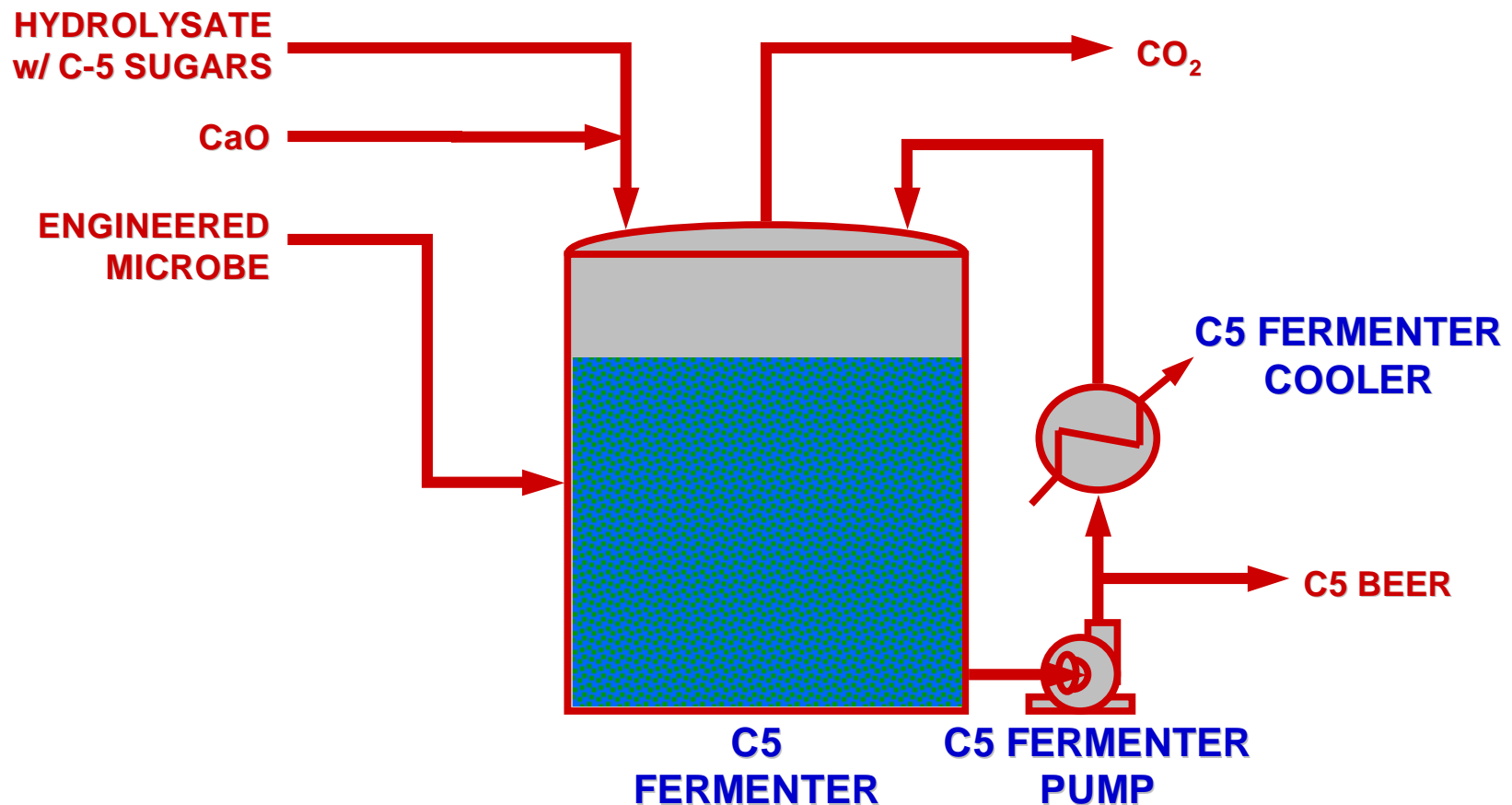
# FLOW DIAGRAM

## *"MILD ACID HYDROLYSIS"*



# FLOW DIAGRAM

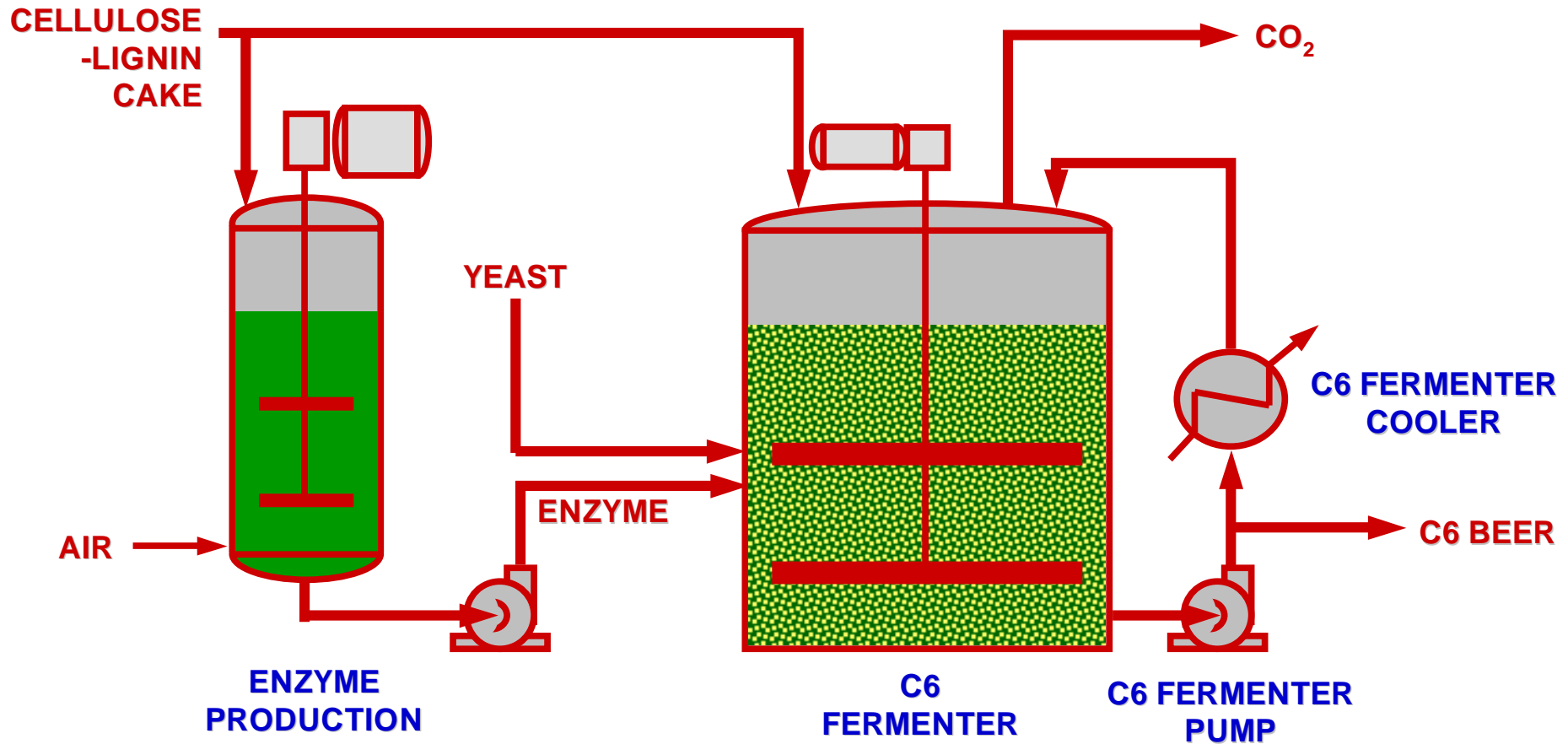
## *"C5 FERMENTATION"*



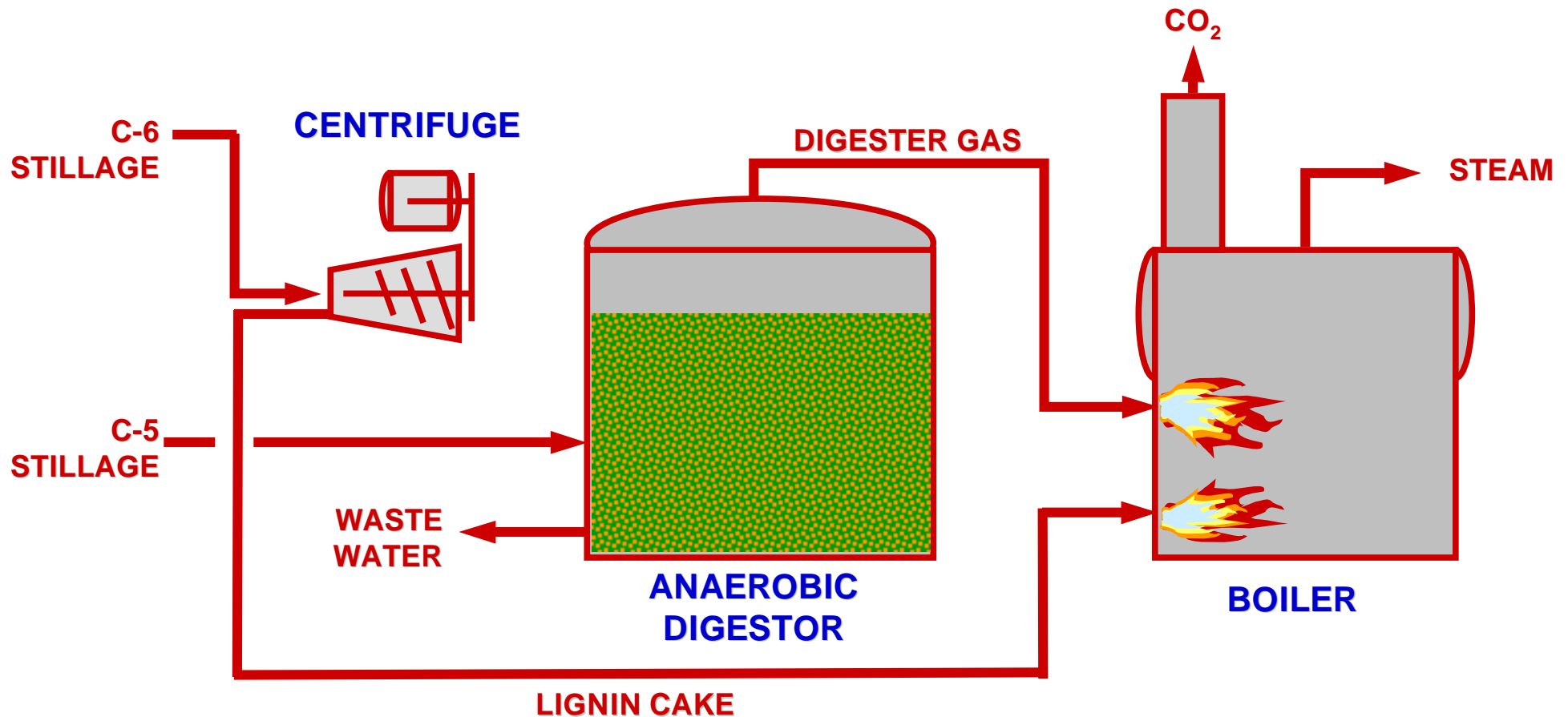


# FLOW DIAGRAM

## *"C6 FERMENTATION (SSF)"*



# FLOW DIAGRAM “STILLAGE PROCESSING”



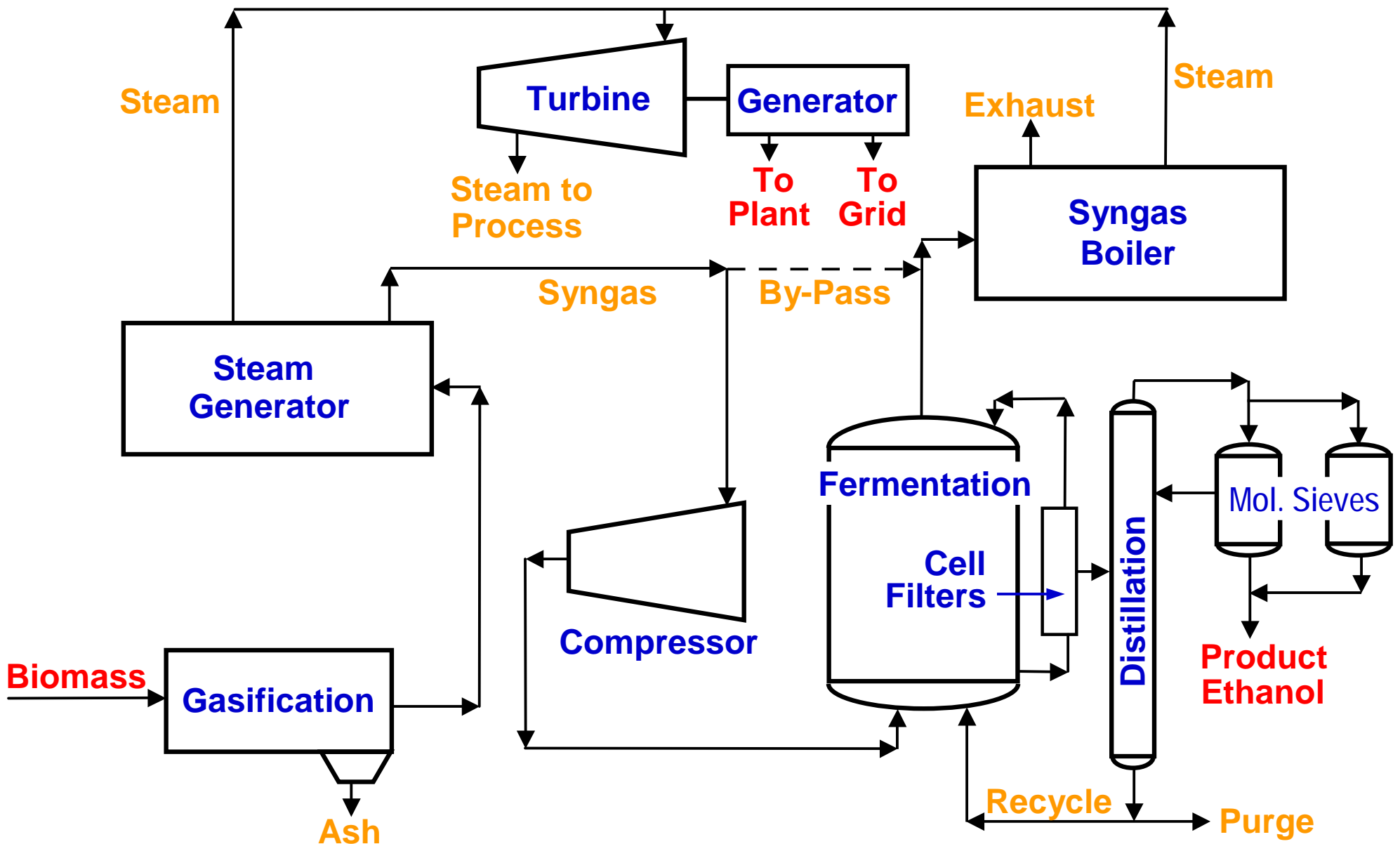
# **GASIFICATION TECHNOLOGIES**











**Power and Ethanol from Biomass**

# BIOETHANOL

SUGAR → STARCH → CELLULOSE

FEEDSTOCK

TECHNICAL COMPLEXITY

COST



**“ ALCOHOLISM ” IS A DISEASE**  
**“ VALUE - ADDED PROCESSING ”**  
**IS A BUSINESS**

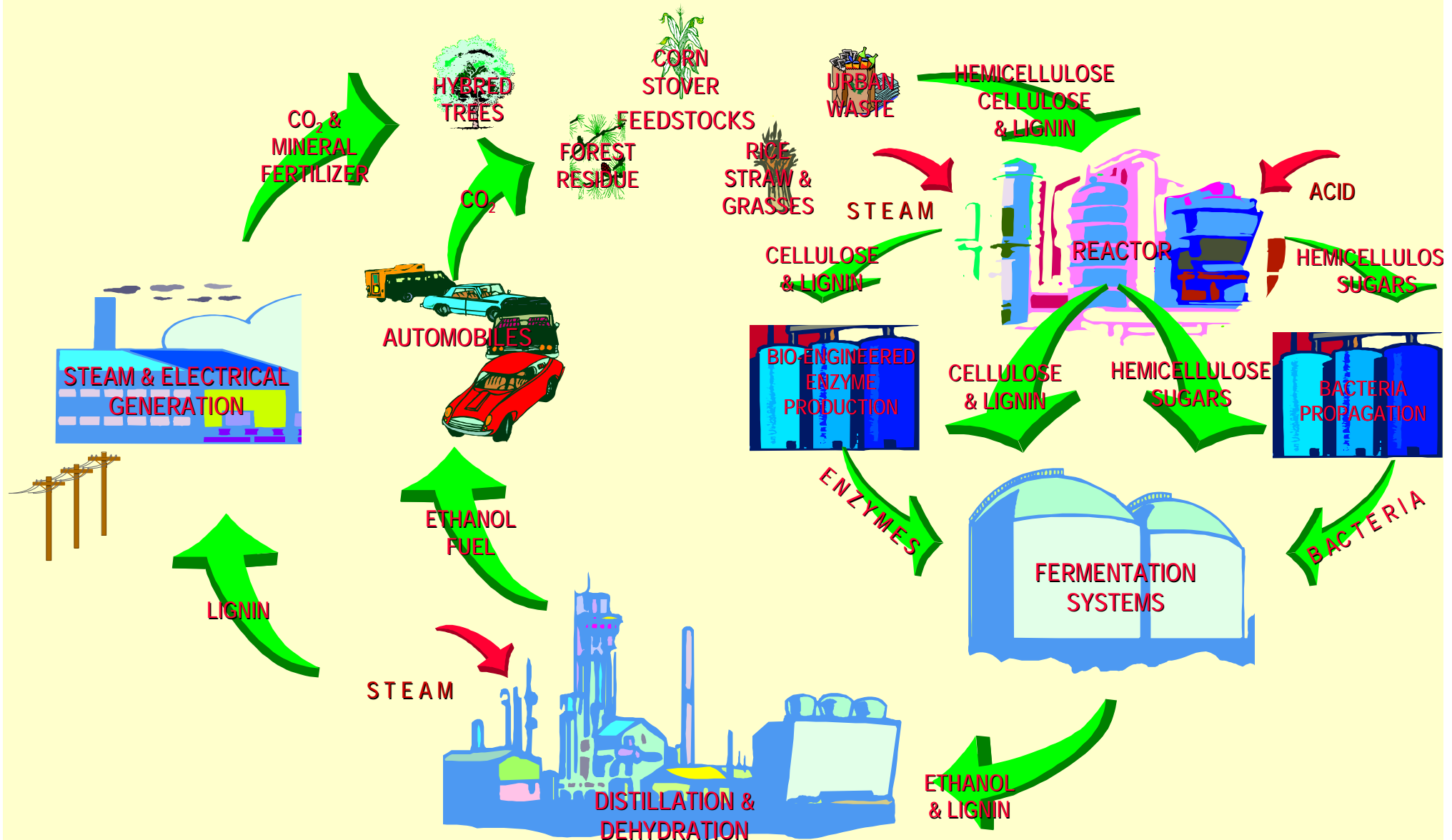
***WE ARE NOT HERE TO MAKE ALCOHOL.***  
***WE ARE HERE TO MAKE MORE INCOME***  
***FOR FARMERS - BETWEEN THE CROP***  
***AND THE COW MANURE.***



**WITH PROPER  
POLICIES  
MONTANA  
WILL HAVE ...**

# BIOREFINERIES

“PROCESSING THE SWEETEST CRUDE IN THE WORLD”





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